Building Technologies Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

S&C PEER REVIEW

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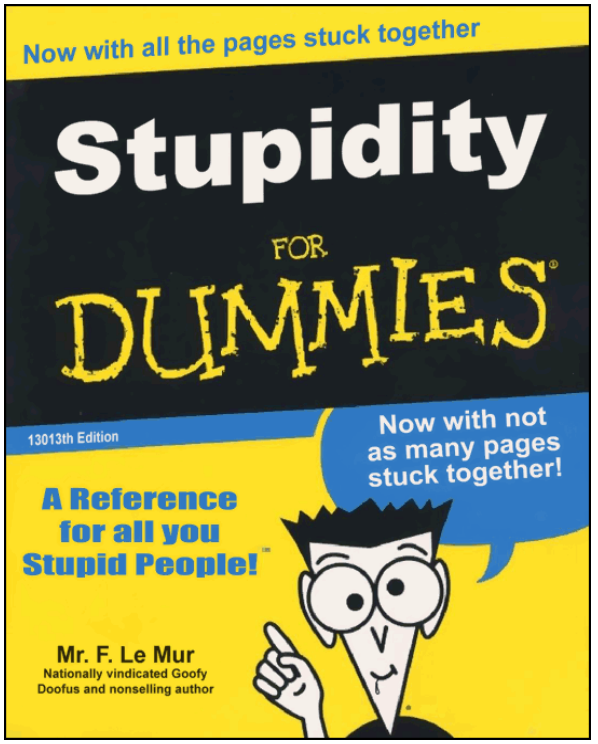
Smart buildings today are not too smart…

Examples:

- Existing sensor/control systems do not self-configure , self-setup, or self optimize driving cost up to “get it right”
- Thermostats are typically deployed across too large a space to properly condition the building for comfort
- Advanced sensor/control systems are too expensive thereby “taxing” optimization
- Existing sensor/control systems are not capable of adequate diagnostics offering no automatic fault detection or response
- Lighting control is typically independent of thermal control yet the effects are dependent
- Occupancy sensors are expensive to deploy yet rarely operate effectively
- Building devices/equipment typically cannot communicate with each other
    - Building management systems provide minimal control and are only cost effective for larger buildings.

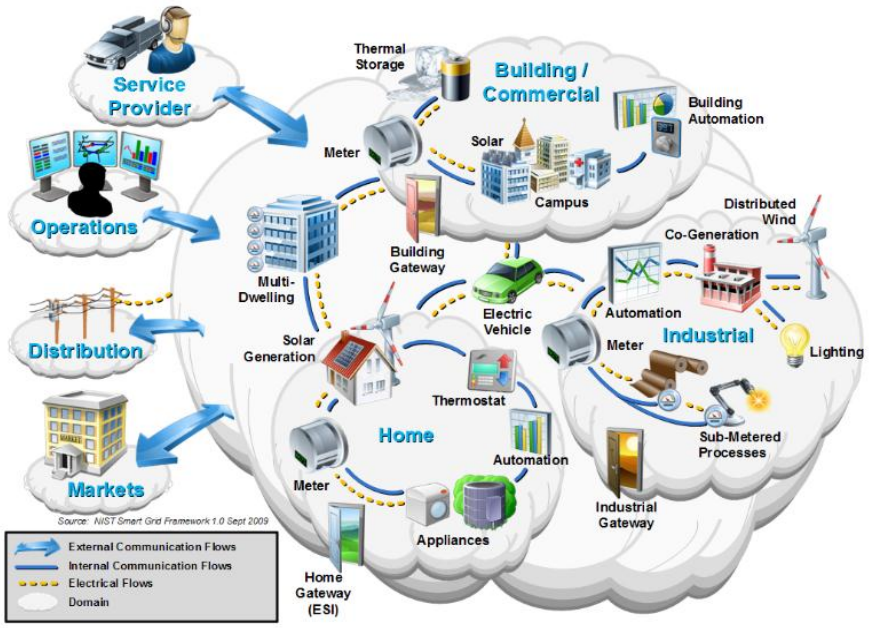


Smart buildings start with smart sensors and controls.

Smart buildings lead to better utilization of energy at all scales

- Buildings need to be smart to participate in transactions within the building, with other buildings, and with grid entities.

- Sensors and controls at the whole building level and at the component level are fundamental to optimize DER and the grid.
  - Hypothesis: *The financial viability of building efficiency may be sub optimized since margins are thin. Grid integration (i.e. demand response) alone is not financially viable in many instances, BUT… a model with multiple transactions within an energy ecosystem enhances the value proposition.*



- All BTO Sensors and Controls projects are designed to improve building performance and incorporate the broader transaction capability.

Advanced controls are transaction based controls

Transaction Based Controls are a “no regrets” solution for EERE

- Next generation building sensors/controls can be low cost and offer significant energy savings for buildings and other technology sectors
  - BTO-AMO Alcoa project

- The BTO prioritization tool indicates that various building controls measures have the potential to offer significant energy savings (> ~500 TBTUs in 2030) and are cost effective. These savings are derived from…
  - Commercial building automation, particularly in small and medium buildings
  - Advanced controllers in new refrigeration systems
  - Demand control ventilation in commercial buildings
  - Predictive thermostats in homes and commercial buildings
  - Residential building automation (a sector of high market activity)

- ***Development and deployment of various cost effective transaction based control measures will contribute to 30% energy savings by 2030.***

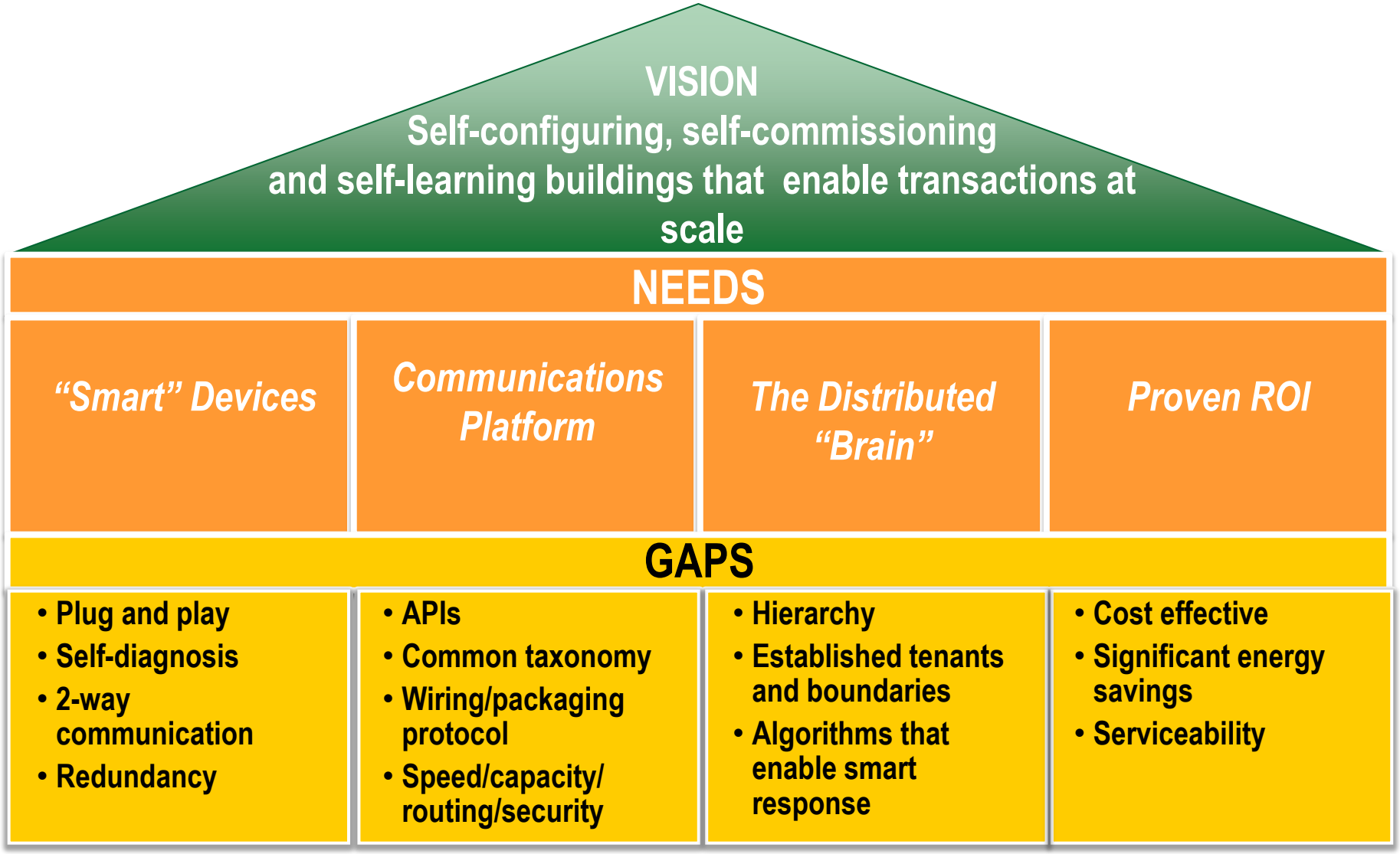
The Transaction Based Control's Vision enables Distributed Energy Resources (DER)

Buildings will be self-configuring, self-commissioning, and self-learning such that they optimize operation, maximize all cost effective energy savings and are enabled to participate in transactions within the building, between buildings, and with the grid

What BTO wants from a Transaction Based Controls program…

We want to…	We don't want to…
Develop a program that maintains a strategic and focused approach to planning, and employs active project management	Fund too many "good ideas" that do not align with the vision and priorities
Support high impact activities that enable a long-term vision focused on transactions, building self-optimization and grid integration	Compete with the private sector or develop potential solutions in markets already served by the "big players"
Enable cost effective and significant energy savings solutions	Rely heavily on lab directed projects/activities without sufficient market input
Support high impact activities that demonstrate the potential for economic benefit to the country	Support projects/activities that reinvent solutions to well-solved problems
Solicit team-based approaches to leverage expertise and the national labs in the "best" way	Support projects/activities that represent individual research agendas
Continuously solicit strategic input from stakeholders	Work on solutions that are self-defined without stakeholder involvement
Ensure BTO is a catalyst that enables open, accessible and scalable solutions, where feasible	Develop proprietary solutions, as appropriate
Ensure BTO's involvement is a proper role for government	

BTO's action on the vision requires identification of needs and gaps



FOA: Open controls platform for small/medium buildings

2013 FOA awarded to CMU, VT, CIEE. FOA was based on Core Funded work in FY12.

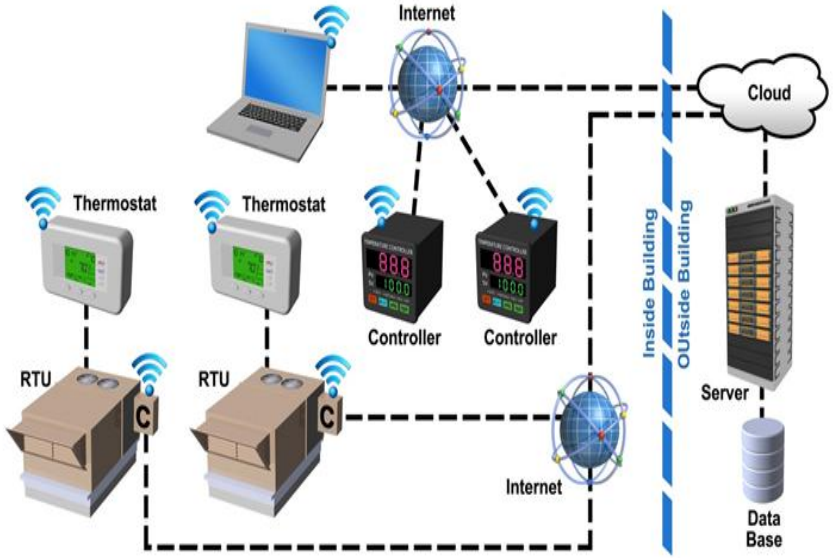
Opportunity: Less than 10% of the buildings in the U.S. use energy saving building automation systems or central controls. Over 90% of the buildings are either small (<5,000 sf) or medium-size (between 5,000 sf and 50,000 sf)

Problem: These buildings currently do not have a cost-effective way to monitor and control their building systems from a central location.

Solution: Development of cost-effective open architecture controls platform for small and medium-sized buildings.

Key Features of platform:

- Open Source
- Open architecture (interoperable)
- Plug and Play
- Auto mapping
- Thermostat, lighting, plug load devices
- Grid ready
- Agent based applications



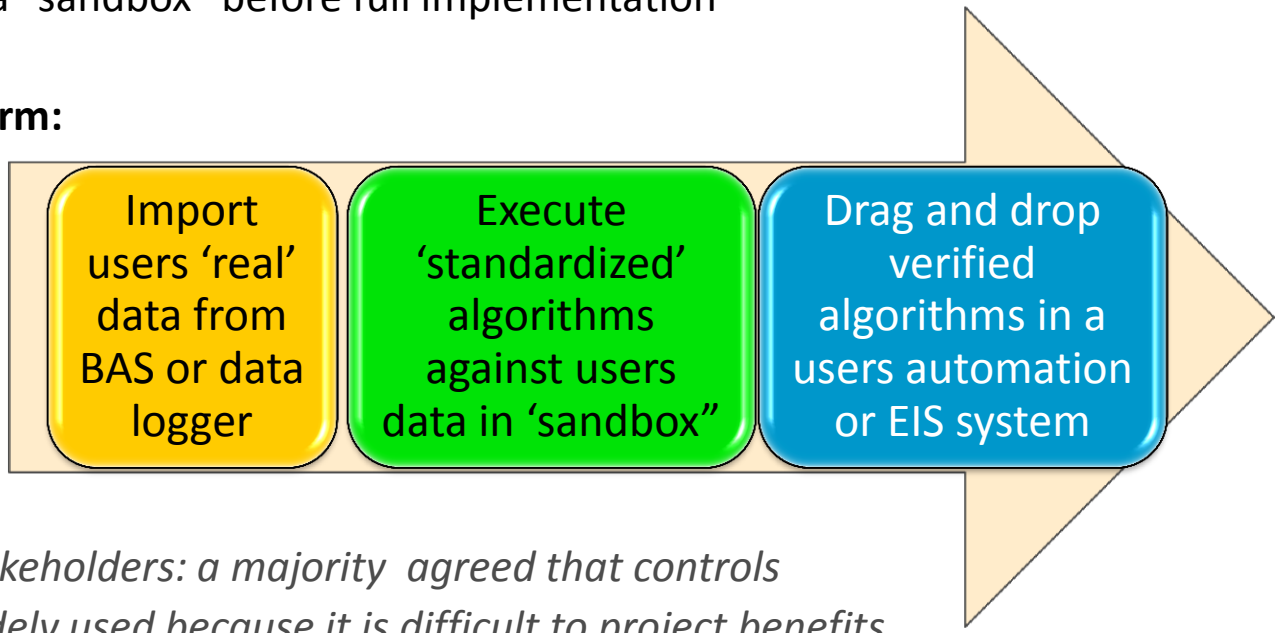
Foundational Projects: OpenEIS

Opportunity: significant energy savings may be achieved by implementing advanced controls algorithms in buildings; requirement for future transaction platform

Problem: controls algorithms stay "in the lab" because the benefits are difficult to project and end users fear negative repercussions from building occupants if they are misapplied

Solution: a "tool" that standardizes deployment of controls algorithms and analyzes benefits using building data in a "sandbox" before full implementation

Key Features of platform:



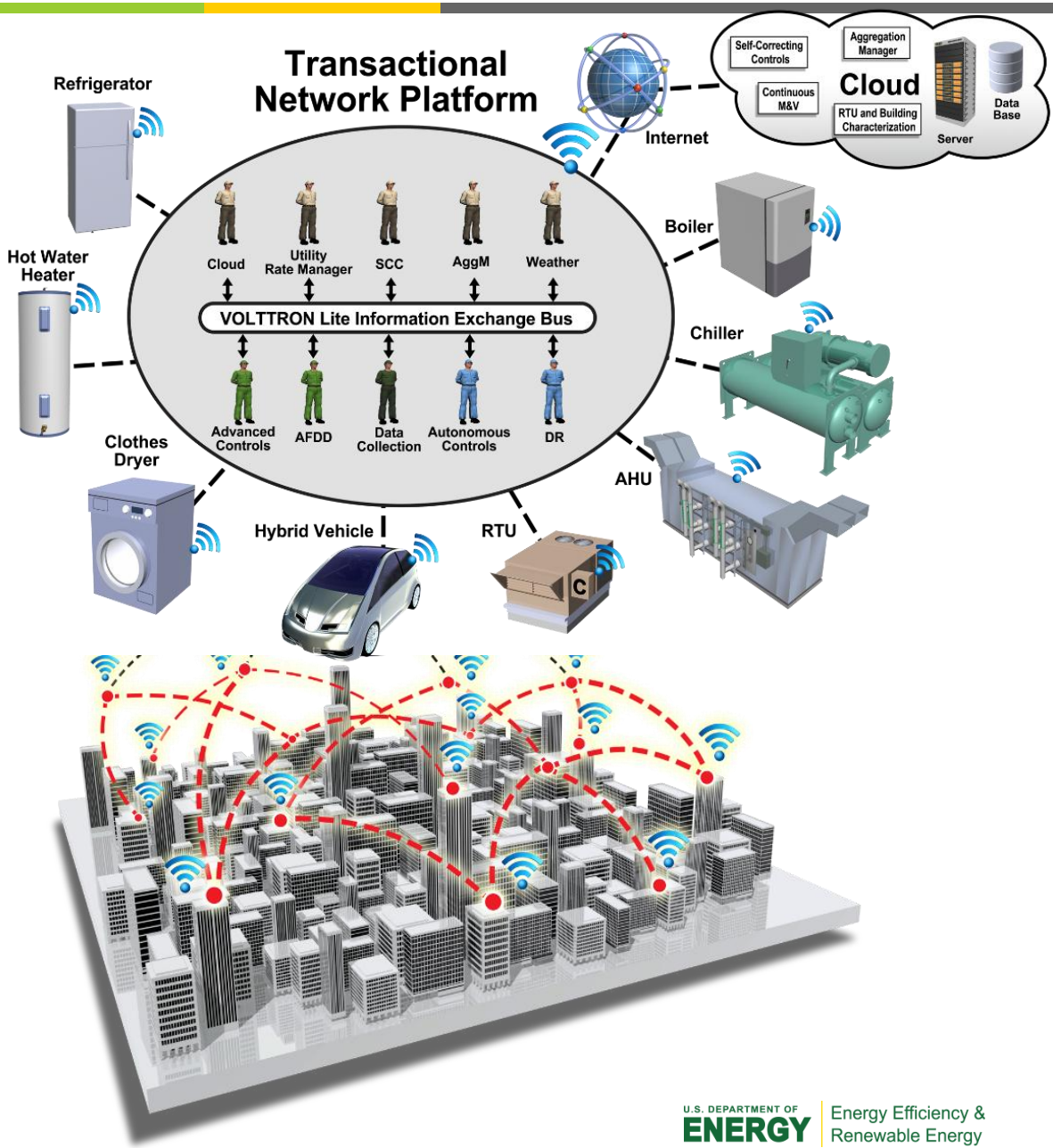
Navigant survey of stakeholders: a majority agreed that controls algorithms are not widely used because it is difficult to project benefits and risks; a "tool" could facilitate adoption of valuable controls strategies

Foundational: Transactional Network Controls

- Buildings need to be smarter to participate in transactions within the building, with other buildings, and with grid entities.
- Sensors and controls at the whole building level and at the component level are fundamental to optimize DER and the grid.
- **The transactional network enables energy saving retrofit solutions**

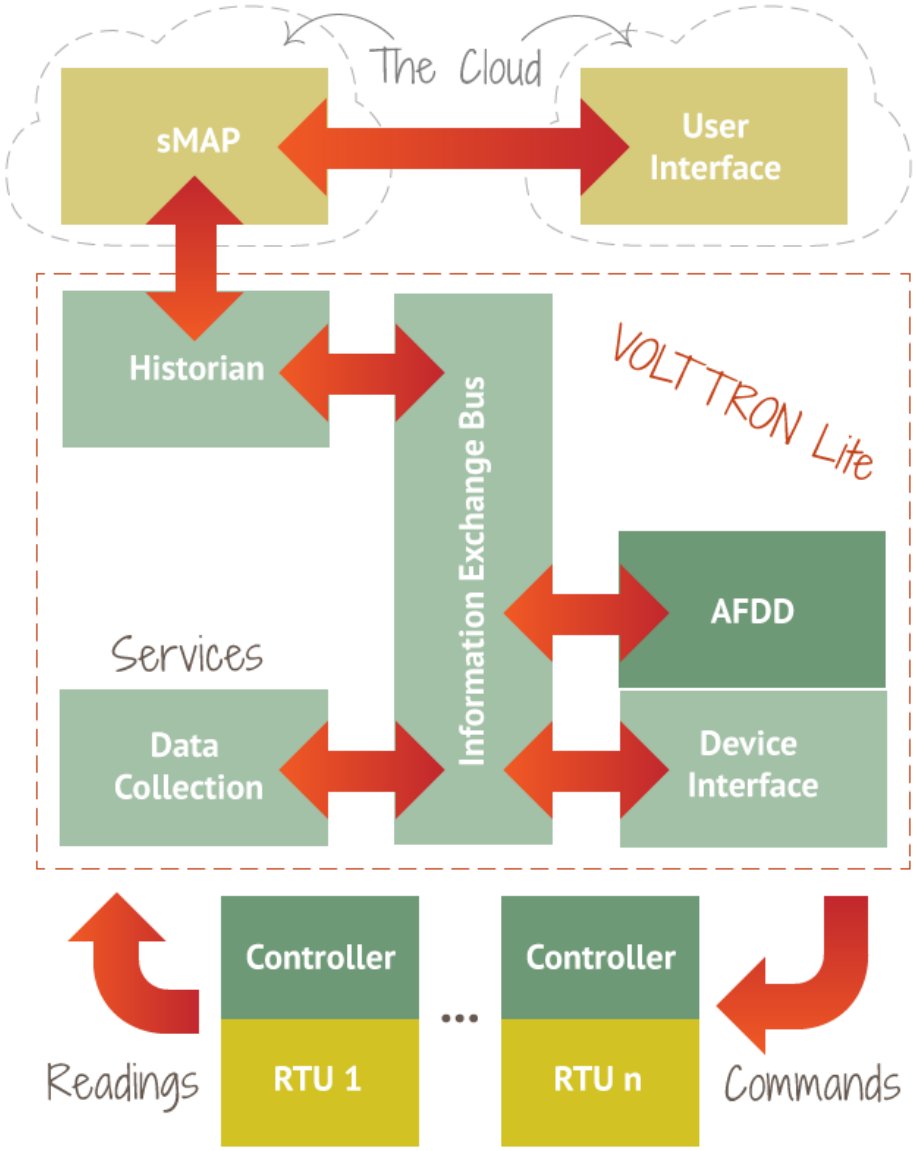
  AND

  The networked systems to transact with all grid connected devices (e.g. EV, storage) and with the grid to help mitigate DER related disturbances.



Foundational: Transactional Network utilizing building controls

- Initially, the transactional concept is demonstrated using networked RTUs with a control solution living in the cloud.
- In the future, the concept can be extended to network other building systems (RE, PV, Storage), interaction between buildings and electric vehicles all using an open source software platform (VOLTTRON)
- Work is being done at the national laboratories to adapt existing control strategies deployed as a network of software agents. The laboratories deploying the solution are:
  - Pacific Northwest
  - Oak Ridge
  - Lawrence Berkeley

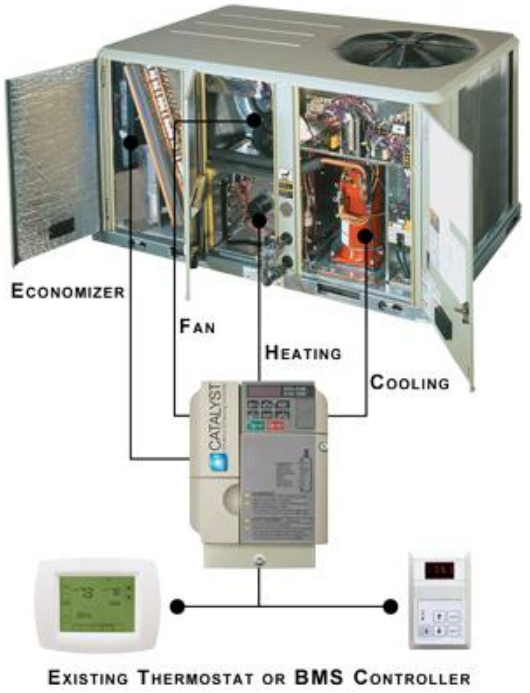


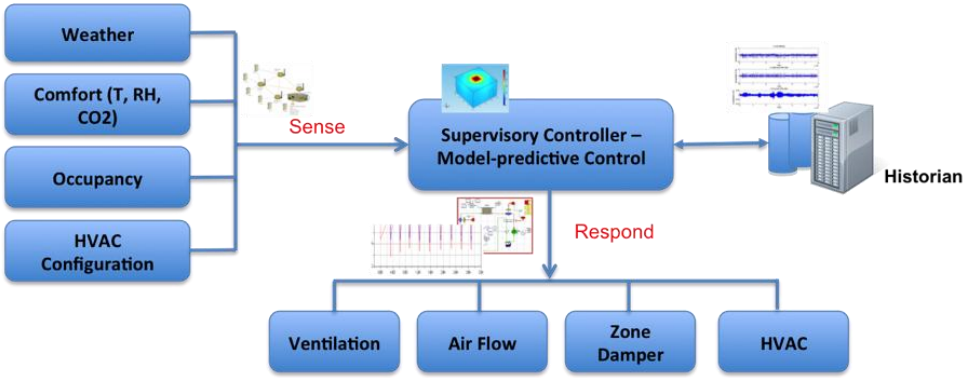
Foundational: PNNL Transactional Network Applications

- **Embedded Advanced RTU Controls** Improve operational efficiency of RTUs through use of advanced RTU controls leading to energy and carbon emission reductions between 30% and 50%

- **Demand Response Agent** Make RTUs grid responsive leading to a more reliable electric power grid and to mitigate variable distributed renewable generation

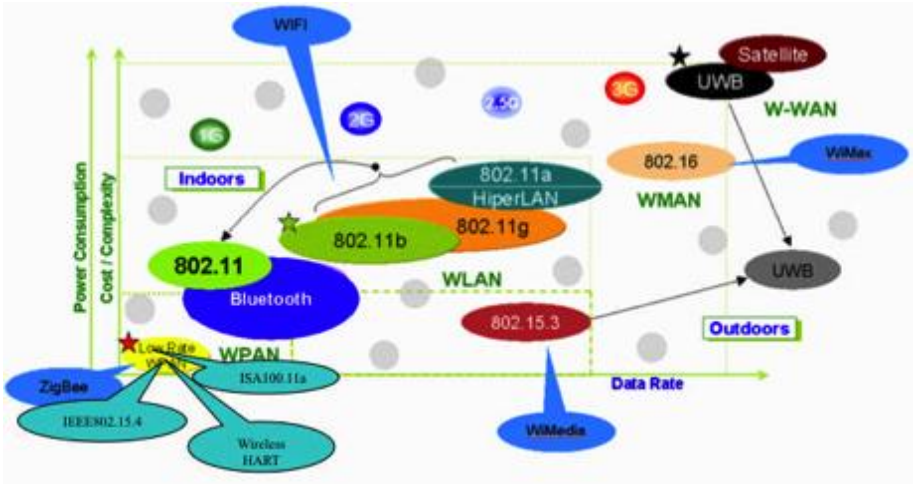
- **Automated Fault Detection and Diagnostics**
  - Detect economizer and ventilation failures as they occur
  - Refrigerant-side performance degradation (or improvement)
  - Energy and cost impacts of the degradation (or improvement)
  - Operation schedule changes
  - Selected operation faults, such as compressor short cycling, 24/7 operation, system never on, and inadequate ventilation

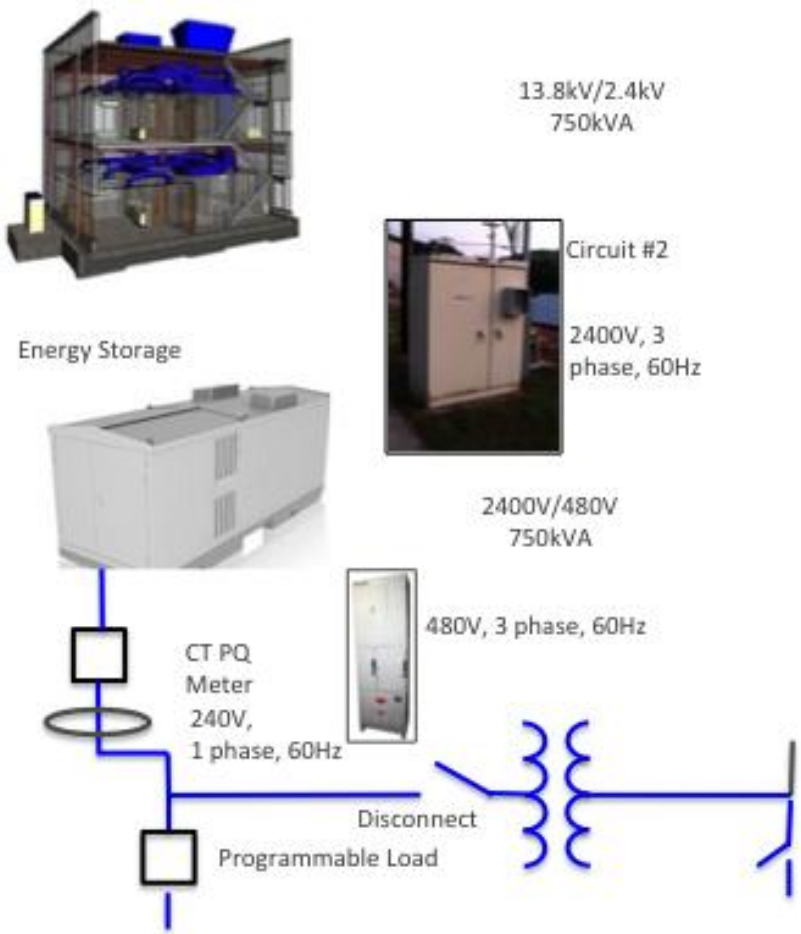




Foundational: ORNL Transactional Network Applications

- **Renewable Integration :** Build autonomous controller to temporally match RTU energy consumption and peak PV generation using forecasting tools
- **Autonomous Control:** Optimization can be performed for particular grid opportunities (load reduction, voltage regulation, renewable integration) and EE applications (occupancy, weather forecast).
- **Wireless Interoperability:** Seamless integration of wireless sensors into transaction network platform



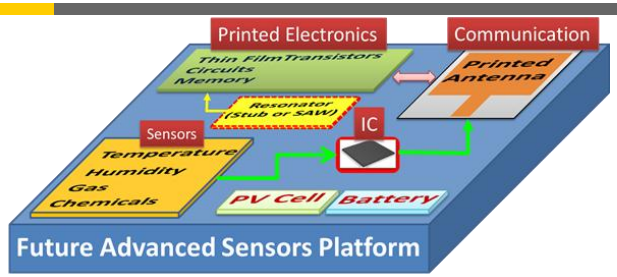


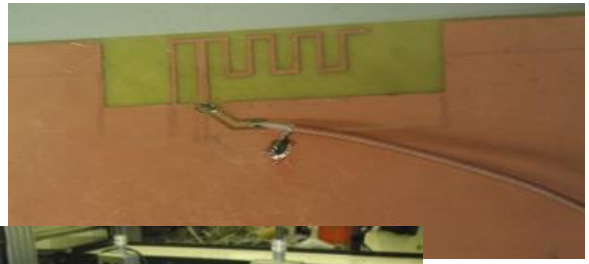
Foundational: $1 Wireless Sensor Platform

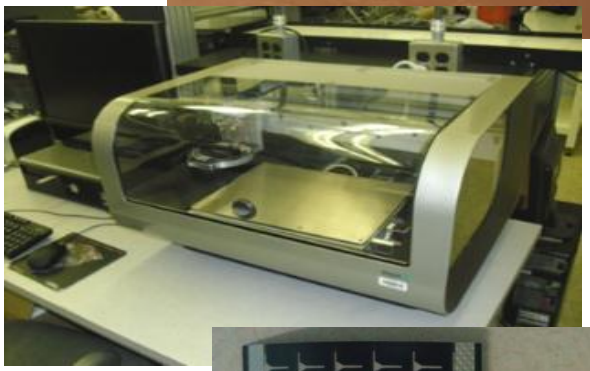
Solution: Low cost, wireless sensor platform that are fully printable "peel and stick" at a cost of $1-$10/node vs. $150-$300/node

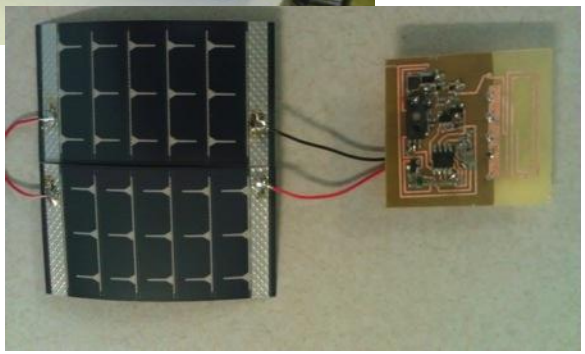
FY13 goals (metrics): Develop fundamental research for a printed, multi-sensor platform

- Comprised of new high performance materials using unique low temperature thin film printing
  - Integrated system utilizing printable sensors (e.g. metal-on-plastic technology)
  - Printable PV using amorphous silicon with on-plastic chip integration
  - Printable antenna and resonator designs
- Performance specifications:
  - Transmission rate: every 80 seconds
  - Power harvesting from ambient light: office lights (fluorescent lamps)
  - Parameters measured: Temperature, humidity, light intensity
  - Range: 50 feet (tested), expected range (2K-3K feet)
  - RF frequency: 315 MHz
  - ~10-15yr life









Metal on Plastic Printing & Curing